conditions. This difficult conversion is not simplified by the fact that both the source system and the target system are interlaced 2:1.

3. with MPEG

The DigiCipher HD decoder would require modification to decode MPEG or H.261. The proponent states that there would be only a modest increase in complexity because DigiCipher shares many commonalties with MPEG and H.261. MPEG and H.261 decoders will not decode DigiCipher HD.

4. with still image

The proponent has identified still-frame as a useful capability, and believes that forward compatibility with JPEG, Photo CD and CDI is feasible and is a marketplace issue. The frame-coding option offered by the proponent (See I.F) enhances compatibility with still images.

K. Scalability

Though the receive and display clocks are currently linked, the proponent proposes to operate them independently in the future. The receiver could then receive non-real-time video at slower rates.

According to the proponent, picture-in-picture and picture-out-of-picture are possible with DigiCipher as receiver design options.

L. Other Compatibility Features

DigiCipher HD processes the image in four parallel panels. Each panel processor is comparable to a DigiCipher NTSC processor and thus is able to process a DigiCipher NTSC signal. There is also a compatible bus that can support both NTSC and HD signals. The proponent claims that the compatibility extends to VCR's, and satellite and cable receivers.

II. Scope of services and features

A. Initial Use of Ancillary Data

The use of the ancillary data capacity is not yet specified.

B. Audio

The DigiCipher system provides for four independent audio channels, each sampled at 47.2 kHz (to be changed to 48 kHz) and digitized to 16-bit precision. The system uses two Dolby AC-2 compression systems operating at 24-bit precision. The two compressed audio data streams are formatted along with a 1200-bps control signal into a single serial output data stream at 503 kbps, to be multiplexed into the transmitted signal. The system description discusses extra error protection within the Dolby AC-2 decoder. This leads to audio that remains acceptable under signal conditions where the picture fails.

The proponent has proposed to incorporate the Dolby AC-3 composite-coded 5.1 channel surround-sound system into the prototype prior to field testing. This system offers a variety of modes of operation, including dual independently coded AC-2A channels. The proponent also suggests that the use of packetization will permit potentially numerous composite-coded and independently coded audio channels to be transmitted, with the receiver determining which to process.

C. Data

A 126-kbps channel is provided for ancillary data. This is distinguished from a separate 126-kbps channel assigned for conditional access use. The planned incorporation of packetization at the transwitch layer will allow the system to flexibly allocate transmission capacity to data.

D. Text

In the prototype, four data channels at 9600 bps were implemented to illustrate asynchronous data transmission.

E. Captioning

The proponent has stated an intention to demonstrate closed-captioning compatibility when prototype captioning hardware becomes available in mid-1993.

F. Encryption

Encryption was not implemented in the prototype. However, the proponent claims to have developed "smart card" security for both VideoCipher and DigiCipher. With packetization by data type, the different types of data will be encrypted separately.

G. Addressing

A 126-kbps channel is assigned for conditional access use (subscriber addressing), separate from the 126-kbps channel for auxiliary data. The proponent suggests that with this data channel, 50-100 million receivers could be addressed in less than one day. The proponent offers to implement fully packetized data that will allow flexible allocation of data with increased peak-load subscriber-addressing capability.

H. Low-cost receiver

The proponent suggests a low-cost receiver that displays 176 x 120 pixels by extracting and processing only the DCT DC coefficients. Picture quality is suggested to be comparable to that of NTSC on a 2" LCD display. Extracting the DCT DC coefficients for a low-cost receiver can be implemented in any of the proposed digital systems.

I. VCR capability

A consumer-grade VCR has been publicly exhibited by GI and Toshiba. It records a digital signal at the 18.2 Mbps information rate of compressed DigiCipher. It uses two-hour metallized-tape cassettes, similar in format to 8-mm NTSC cassettes.

The proponent reports running simulations, showing that a full set of trick mode features can be supported. The DigiCipher VCR uses PCM refresh data from each field, and attempts to use DPCM data too.

Switching between compressed video images should be done at frame sync, preferably with the new scene either at black or at a scene change when the image is being processed in the PCM mode. Switching within a frame may be done at the macroblock level, with some restrictions. Otherwise, editing during frames requires decompression and recompression, with a small loss in quality do to concatenation. However, it is anticipated that most editing will be done prior to compression to the transmission rate.

No provisions have been reported for special effects in the system tested.

III. Extensibility

A. to no visible artifacts

The proponent reports simulating compression at 30 Mbps with favorable results. He believes that the algorithm can be extended to 40-45 Mbps, constituting a distribution level of quality suitable for network feeds to local affiliates. The proponent has announced that he is investigating an approach which would allow the transmission-level signal to be included in the distribution level signal as a kernel. This would permit pass-through of the transmission-level signal at the local affiliate level by stripping away the distribution-level augmentation.

B. to studio-quality data rate

The proponent speculates that studio-quality intraframe compression can be achieved at a bit rate in the 100-200 Mbps range. This format has not been developed yet.

C. to higher resolution

The proponent believes that DigiCipher technology is extensible and suggests a resolution increase by a factor of about four.

D. Provision for future compression enhancement

The proponent suggests that as decreasing digital processing costs enable increasing complexity at the encoder, improvements can be made without changing the receivers or the transmitted bit rate. These improvements are in forward analysis, perceptual analysis, motion compensation, coefficient quantization, and special effects editing.

Digital Spectrum Compatible HDTV
Interoperability Assessment

System Description

The Digital Spectrum Compatible HDTV System is an all-digital system that is progressively-scanned with 787.5 lines per frame and 59.94 frames per second. The display format has square pixels with 720 lines by 1280 pixels per line in a 16:9 image aspect ratio. A feature of the system is dual-rate coding where each data segment is assigned a priority. The most important picture information on a scene-by-scene basis is transmitted as two-level vestigial sideband (2-VSB) while the remaining picture information is transmitted as 4-VSB. This allows a degree of graceful degradation on the edge of the broadcast contour and transmission robustness within the service area. It also allows a degree of bit-stream scalability. It implies a picture-dependent variable information rate, achieved with a constant symbol rate. A pilot carrier is used for easier signal acquisition because the pilot carrier is in a part of the band where co-channel NTSC receivers are not sensitive.

I. Interoperability

A. with Cable TV

The tests of the proponent systems at ATTC by Cable Labs should determine the critical aspects of interoperability with cable TV. Other factors that may aid cable TV interoperability include channel augmentation to 9 or 12 MHz for improved picture, or better, going to a higher data rate that can be supported in the 6 MHz channel by the relatively benign cable environment. The proponent claims the hardware implementation of a 16-VSB transmission format to achieve a 43 Mbps data rate, which can deliver two DSC-HDTV programs over a single cable channel without any perceptible increase in the cost of terrestrial broadcast receivers.

Encryption and addressing are important service features for Cable TV. See Section II, items F and G.

B. with digital technology

Since this system is all-digital, the advantages of all-digital systems apply.

C. Headers/descriptors

The prototype tested did not have explicit headers and descriptors. However, ancillary data space was provided for a number of purposes including headers/descriptors. A data format is presently under development that includes a minimum of fixed data. Within that fixed data is a location system header that specifies the use of the remaining data. The use of data is flexible, and the header deals with error correction and priority transmission of the data. Detailed information was provided to the Review Board.

D. with NTSC

As the Digital Spectrum Compatible HDTV system is directly related to NTSC, transcoding to NTSC is straightforward. Conversion to and from NTSC has been demonstrated using real-time hardware. Edge-crop conversion to CCIR 601 involves discarding 160 HD samples from each end of the horizontal line and 4:3 interpolation of the remaining samples. It can involve 3:1 and 2:1 vertical interpolations in alternate fields. For letter-box, 16:9 horizontal interpolation is required, as well as 3:1 vertical interpolation of the active lines. For edge-crop display, the 480 lines can be placed in a specific set of the 483 active lines. The first (odd) field can be displayed on lines 21, 23, ..., 499, and the second (even) field is displayed on lines 22, 24, ..., 500. The active lines 501 and 503 of the odd fields and 502 of the even fields can be displayed as black. For letter-box display, the vertical interpolation is more complicated. Up-conversion from NTSC requires line tripling, horizontal line-rate conversion and interpolation.

E. with film

The encoder buffer control automatically detects the presence of 24-frame/second or 30-frame/second scene material from film sources. When a film source is detected, an alternate buffer control algorithm is used which takes advantage of repeated frames in the source and minimizes variations in distortion between repeated frames. If film is detected, all video segments undergo two-level-mode transmission for maximum coverage area and minimum video data rate. The current implementation of the alternate buffer control for film mode was not completed in time for testing at the ATTC. However, it has since been completed and demonstrated.

F. with computers

Progressive scanning and square pixels, both used in this system, are important factors for interoperability of an HDTV system with computers -- nearly all existing bit-mapped computer graphics displays have these features. Progressive scanning and square pixels are most critical for real-time applications such as display, scan-conversion, frame capture, and video effects. Computers are expected to play an increasing role in video image generation and production, and it is desirable to have an HDTV format which allows direct display and manipulation of HDTV video on the computer. Progressive scanning is preferable for computer applications to avoid artifacts that are common with interlaced display of computer generated imagery. Also, scan conversion between interlaced and progressive systems can produce undesirable artifacts. Square pixels are inherent to graphics display hardware for all popular computers employing bit-mapped displays. The main reason is that it facilitates processing of 2D transformations, especially rotations. It also helps format conversion and extension to higher resolution.

G. with satellites

Digital signals with bit rates used by the proponents for terrestrial transmission can generally be accommodated in the available bandwidth of a satellite transponder. The maximum total data rate for the DSC-HDTV system in the mode tested by ATTC is 21.5 Mbps. As satellite data communication channels use a constant bit rate, the variable bit rate used by DSC for terrestrial transmission makes it necessary for the bit stream to be reformatted for satellite transmission. The reformatted bit stream must contain the data needed to permit reconstruction of the variable-rate bit stream for VSB-2/4 terrestrial modulation. Nevertheless, DSC-HDTV has the lowest data rate of any of the all-digital proponents. The proponent has suggested two-channel TDM and two-channel SCPC in a 36-Mhz transponder and two and one channel DBS scenarios.

H. with packet networks

The DSC symbols are organized in data segments that resemble packets. The segments make up data frames of duration 1/59.94 sec. In order to carry DSC on an ATM network, the data in data frames would be encapsulated in the ATM cell structure. However, circuit-switched networks use constant bit rate, while the number of bits in a data frame varies because of the two-level transmission. The proponent suggests repeating two-level segments for added robustness to fill out the data stream for a constant-bit-rate channel. For a packet network, packets can be used as needed to carry the lesser actual bit rate.

When cell loss is detected, the decoder performs error concealment by replacing missing segments with default data or with pixel data from a previous frame. The error concealment algorithm was only partially implemented for ATTC testing, but has since been fully implemented.

I. with interactive systems

The picture achieves full quality within a few frames after a scene change. Full quality is obtained within one second after a channel change.

Latency is the time delay between a video frame going into the encoder and the corresponding frame coming out of the decoder in the back-to-back mode. It can be important in interactive applications. Frame delays are required at the transmitter and at the receivers for coding and decoding. Rate buffers at the transmitter and at the receiver cause additional delays. Furthermore, the system implemented for test may not be representative of the minimum delay possible. Comparison of latency between the proponent systems is difficult at this time.

The proponent claims that the delay through the encoder and decoder for the DSC-HDTV system is about 14 frames (224 ms). An enhancement to the current system allows the latency to be determined by the encoder, in case lower latency is required for interactive applications.

J. Format conversion

1. with 1125/60

Up-converting to the Common Image Format (1920 x 1080) is easily done by 2:3 interpolation horizontally and vertically. SMPTE 240M currently uses 1035 active lines. Colorimetry is SMPTE 240M.

2. with 1250/50

Conversion between systems with different frame rates is the most difficult type of conversion presently being done. Digital conversion between 59.94 fields per second and 50 fields per second requires a number of frame stores and very large processing capability. Present methods that involve frame dropping lead to jerky motion, but other techniques can produce acceptable images under most conditions. This difficult conversion is somewhat easier with a progressive system such as DSC than with an interlaced system.

3. with CCIR 601/60

The proponent claims that conversion to and from CCIR 601/60 has been demonstrated with excellent results. Commercially available line doublers were used to convert the CCIR 601 to progressive form, followed by a spatial interpolation.

4. with MPEG

Although the DSC-HDTV decoder shares many commonalties with MPEG1 decoders, the DSC-HDTV decoder would require modification to decode MPEG1.

5. with still image

The proponent suggests that conversions with JPEG, Photo CD and CDI are possible with straightforward spatial filtering after decompression, without the temporal effects that might be introduced in an interlaced TV format. In simple cases, line and sample doubling or sub-sampling will suffice.

K. Scalability

It is possible to process the two-level data only and display the images corresponding to that portion of the video information. Film scenes and many normal video scenes will use almost entirely two-level coding for video, so the two-level data will result in virtually full-quality video. The decoding of only the two-level data may result in a reduced-quality image for scenes that are difficult to encode and that therefore require substantial four-level data. In such a case, the loss of the four-level data affects both the temporal and spatial resolution. The error-concealment algorithm replaces lost slices with information from a previous frame. Another spatial scaling method would produce a lower resolution picture by extracting a lowest frequency subset of the DCT coefficients from each compressed slice. Extraction of only the DC coefficients would produce a 160H x 90V pixel image. Scalability by extracting DC (or other low-order) DCT coefficients can be implemented in any proposed digital system. Where temporal scaling is needed, the process is simplified by the progressive scan used in DSC. The proponent has suggested using the motion vectors available at the decoder to perform motion-compensated frame interpolation.

The proponent suggests that picture-in-picture be done by windowing on slice (64H x 48V pixels) boundaries.

II. Scope of services and features

A. Initial Use of Ancillary Data

The proponent has provided charts showing a way in which flexibly allocated data may be used by means of headers. See Section I.C, Headers/Descriptors.

B. Audio

The DSC-HDTV system provides four independent 125,874 bps audio channels multiplexed with the video data. The prototype hardware used the Dolby AC-2 compression equipment. The main stereo pair is transmitted as two-level VSB, whereas the secondary pair is transmitted as four-level VSB. The two-level data has a 6 dB lower threshold at the fringe area.

The newly proposed use of headers provides a flexible composite surround-sound method, described in ATSC document T3/186, in place of the original fixed allocation. It also provides a separate stereo pair suitable for a second language.

C. Data

Two separate channels were provided for ancillary data in the system tested. The total capacity of 412,867 bps was divided into one channel of 30,210 bps sent as 2-level data and another of 382,657 bps sent as 4-level data. However, the newly proposed header usage allows a much more flexible assignment of ancillary data capability. Assuming the presence of video, five-channel audio, and captioning, and that all the ancillary data is carried as four-level data, the ancillary data rate is 493,426.57 bps.

D. Text

The technical description dated 2/22/91 suggested that 35 bytes per data field or 16,783 bps be used for teletext. The new proposal would flexibly allocate text data by use of headers and descriptors.

E. Captioning

The technical description dated 2/22/91 suggested that 1 byte per data field or 480 bps be used for captioning. The new proposal would allocate 9.6 kbps per ATSC Document T3/186.

F. Encryption

The prototype tested did not have encryption implemented. The proponent expects to develop encryption with industry participation.

G. Addressing

The use of headers under development allows program quality to be traded temporarily for addressing performance. An extreme mode of the system in which most of the data rate is dedicated to addressing would allow addressing of more than 5.7 million subscribers per minute. In this mode, other auxiliary data would be suppressed, and a minimum quality of audio/video service would be maintained.

H. Low-cost receiver

The proponent described an algorithm for producing a 640H x 360V pixel image by extracting one out of four 8x8 blocks of pixels and tiling them. The resulting picture is said to exceed the quality of NTSC on a 2" LCD display. It is also reported possible to make a low-cost receiver with just the two-level data.

I. VCR capability

The proponent claims that the current S-VHS mechanism is sufficient for the 21.5 Mbps compressed DSC-HDTV data, and that such 1/2 inch cassette equipment exists in prototype form.

According to the proponent, the system knows what fraction of the original image is contained in the displaced frame difference (DFD). A usable picture is obtained without motion compensation by amplifying the DFD by a factor proportional to the inverse of the DF factor. This can be used for VCR forward or reverse scan modes when only a small portion of each compressed frame is acquired. In addition, the segment headers are needed to identify the slice numbers from the acquired data. The picture would appear "blocky" with some slices lost, but suitable for rapid searching.

Still frame is simple if the VCR had been playing. If random access to a particular frame on the tape is required, the decoding of several frames leading up to it is needed to achieve full quality.

Splicing is optimal if each splice starts with a scene change. Otherwise, the decoder can be signaled to initiate a leak factor inversion for fast startup at the beginning of each splice or insert.

Cropping is possible by manipulation or replacement of compressed slices.

Image processing for special effects is best performed in the pixel domain after decoding. Square pixels and progressive scanning simplify the implementation of special effects.

III. Extensibility

A. to no visible artifacts

It was the reported intention of this proponent to have no visible artifacts at the terrestrial broadcast data rate, when viewed from a distance of 3 times the picture height. This goal is, however, challenged by complexity and motion. The proponent suggests a rate of 41 Mbps for no visible artifacts regardless of detail and motion, and states that this can be accomplished with a small change to the compressed video interface.

B. to studio-quality data rate

Claims are made that the compression techniques used for the broadcast of DSC-HDTV are easily simplified to produce a 200 Mbps signal for use in the studio. This signal uses only intraframe processing, and thus is suitable for all editing and special effects processing. The claim is made that the quality may be suitable for multiple decoding/encoding as required. The bit rate is suitable for serial data interfaces and also for video tape recording on D-1 VTRs.

C. to higher resolution

If it is desirable in the future to maintain higher pixel numbers in the production studio, this can also be accommodated in an extension of the studio compression format, by compressing the higher-resolution signal rate into the 200 Mbps studio compression-standard plus a high-frequency residual signal. The standard DSC-HDTV system codes the HD frames, and a simple augmentation encoder codes the residual signal. The final output of editing or special effects can still be recorded using the 200 Mbps portion of the compressed signal.

D. Provision for future compression enhancement

The compression algorithm permits improvements in the selection of vector quantization patterns, motion estimation, perceptual error threshold computation, buffer control, leak adaptation, and transmission prioritization. These improvements can be made without change to the receivers or the transmitted data rate.

Narrow-MUSE Interoperability Assessment

System Description

The Narrow-MUSE system is an analog transmission simulcast system. The input signal format and the display signal format is 1125 scanning lines per frame, 60.00 fields per second, and 2:1 interlace. The transmission format, however, is 750 scan lines per frame, 60.00 fields per second, and 2:1 interlace. The video encoding method is Multiple Sub-Nyquist Sampling Encoding, and the audio encoding method is near-instantaneous DPCM. Transmission is by analog amplitude modulation.

I. Interoperability

A. with Cable TV

The tests of the proponent systems at ATTC by Cable Labs should determine the critical aspects of interoperability with cable TV. Other factors that may aid cable TV interoperability include channel augmentation to 9 or 12 Mhz for improved service. MUSE-E of 8.1 Mhz may satisfy this criterion. An even more desirable feature for a system to offer would be a higher-quality mode within the 6-Mhz channel. Digital systems can do this by sending more bits per symbol, for use over quiet channels such as cable. Since the Narrow-MUSE system is an analog system, it cannot be enhanced in this manner.

Encryption and addressing are other important service features for cable TV. See Section II, items F and G.

B. with digital technology

Since the transmitted signal is analog, it must be digitized before interfacing with digital technology. However, all of the signal processing in the encoder, modulator, demodulator and decoders is done in the digital domain, and custom LSI's are available. A digital interface port is provided in the receiver.

C. Headers/descriptors

This system provides 128 kbps of ancillary data. Although the partition of the ancillary data has not yet been specified, the proponent states that the headers/descriptors as a part of SMPTE 240M and 260M could be assigned into the ancillary data channel of Narrow-MUSE.

D. with NTSC

There are two conversion methods to NTSC. One is from the 750-line Narrow-MUSE transmission format to NTSC, and the other is from 1125/60 to NTSC. Since the aspect ratio of this system, 16:9, is different from the aspect ratio of NTSC, 4:3, a choice must be made for the conversion. The limiting choices for downconversion are 1) "Edge Crop", in which the HDTV picture fills 483 lines on NTSC with loss of the sides of the HDTV picture, and 2) "Letterbox", in which the full width of the HDTV picture is displayed in the full width of the NTSC picture, but leaving unused areas at the top and the bottom of the NTSC screen.

The conversion from Narrow-MUSE to NTSC requires only vertical interpolation because Narrow-MUSE employs an analog transmission technique. Since the number of active lines in Narrow-MUSE is 651, the vertical interpolation ratio is 31:23 for "Edge-Crop" and is 9:5 for the letterbox format.

The interpolation ratio for 1125 to NTSC is 15:7 vertically and 2:1 horizontally. In both conversions, field-rate conversion from 60.00 Hz to 59.94 Hz is required. The proponent claims that a motion-adaptive field-rate converter is available, and has been publicly demonstrated. The proponent also claims that the converter for 1125/60 to NTSC is used for the daily simulcast operation in Japan, that the converter from full-band MUSE to home display is sold on the market, and that the same technique can be applied to Narrow-MUSE.

E. with film

This system does not have a film mode within its encoding algorithm. Since the field rate of this system is 60 Hz, the temporal conversion from film to HDTV is accurate. A motion-compensated continuous-film-transfer telecine is already available for this system.

F. with computers

For computers, a progressive display is overwhelmingly preferred. Interlaced systems such as this have an inherent compatibility problem with computers, even for just displaying the computer's video output. Progressive scanning is preferable for computer applications to avoid artifacts that are common with interlaced displays of computer-generated imagery. Also, scan conversion between interlaced and progressive systems can produce undesirable artifacts. Square pixels are also overwhelmingly preferred for graphics display hardware for all computers employing bit-mapped displays, as it facilitates processing of 2D transformations, especially rotations. Non-square pixels do not present a problem for the display of RGB signals from a computer's video card on HDTV receivers, but would complicate more sophisticated attempts at interoperability, such as the display by an HDTV receiver of a picture from a digital data stream generated by a computer. According to the proponent, the pixel shape of 240M is 1 : 1.043 (H : V), and 1125/60 signals have already been manipulated for graphic purposes. The shape of a decoded Narrow-MUSE pixel is 1 : 0.56. The proponent claims that the field rate of 60.00 Hz is a better selection than 59.94 Hz for interoperability with computers that have integer field rates such as 72 Hz.

G. with satellites

This system can be transmitted through a satellite using FM with an RF channel bandwidth of approximately 15 MHz. FM transmission of MUSE through a satellite is a proven technology. The proponent claims that Narrow-MUSE also can be transmitted through a satellite using digital transmission. The Narrow-MUSE signal can be encoded by DPCM to a data rate of approximately 40 Mbps which includes error correction of 8% (3.2 Mbps). Satellite links typically use more error correction than this, e.g. 14% to 50%. The RF channel bandwidth with QPSK is approximately 24 MHz. Digital transmission of MUSE in conjunction with DPCM is also a proven technology.

H. with packet networks

This item is not applicable because this system employs analog transmission.

I. with interactive systems

The acquisition time is 0.5 seconds.

Latency is the time delay between a video frame going into the encoder and the corresponding frame coming out of the decoder in the back-to-back mode. It can be important in interactive applications. Frame delays are required at the transmitter and at the receivers for coding and decoding. Because the digital systems have other delays, comparison of latency between the proponent systems is difficult at this time.

According to the proponent, the total delay for Narrow-MUSE through an encoder and a decoder is 6 fields (approximately 100 msec), 3 fields for each.

J. Format conversion

1. with 1125/60

No format conversion is required because this system uses 1125/60 format (SMPTE 240M). The decoded Narrow-MUSE signal can be converted to the Common Image Format through a line-number conversion and a sampling-frequency conversion. These are 24:23 vertically and 50:27 horizontally.

2. with 1250/50

Conversion between systems with different frame rates is the most difficult type of conversion presently being done. However, this system makes the frame-rate conversion slightly easier than other systems, because its field rate is exactly 60.00 Hz. The proponent claims that the conversion from 60 Hz to 50 Hz has been successfully demonstrated with a standard converter from 1125/60 to PAL. This standard converter employed interpolation based on motion vectors. The vertical interpolation ratio from 1125 to 1250 is 9:10.

3. with CCIR 601/60

The vertical interpolation ratio between this system and CCIR 601/60 is 15:7 for both total scanning lines (1125:525) and active scanning lines (1035:483). The horizontal conversion ratio is 2:1. The clock frequency for this system, 74.25 MHz, and for CCIR 601, 13.5 MHz, have a relationship of 11:2.

Because the field frequency for this system is 60.00 Hz, field-rate conversion from 60.00 Hz to 59.94 Hz is required. A motion-adaptive field-rate converter is available and is used daily for simulcast in Japan. A frame skip must take place every 33 seconds, because of the 1001/1000 frame conversion. The hardware attempts to do this cut on a motionless picture or on a scene change.

4. with CCIR 601/50

The vertical conversion ratio between Narrow-MUSE and CCIR 601/50 is 9:5 for both total scanning lines (1125:625) and active scanning lines (1035:575). The horizontal ratio is 2:1. The clock frequency for Narrow-MUSE, 74.25 MHz and for CCIR 601, 13.5 MHz, have a relationship of 11:2. Also, see item 2 above.

5. with MPEG

Narrow-MUSE does not have interoperability with MPEG.

6. with still image

An 1125/60 still image disk system based on the JPEG algorithm has been developed and demonstrated. The system uses multiple disks, with video, audio, and control data recorded on separate disks. Narrow-MUSE does not have compatibility with JPEG, Photo CD, or CDI.

K. Scalability

This system uses a multiple sub-sampling technique with a four-field sequence. Therefore, the spatial resolution of the reconstructed picture can be controlled by selecting fields to be used for the interpolation. When all four fields are used, a full-quality picture is obtained. When one of every four fields is used, a picture with reduced resolution can be obtained by interpolation. Also, a picture with reduced size can be obtained by using only a selected field.

The proponent claims that Narrow-MUSE is a member of the MUSE family, which is based on the concept of scalability. The MUSE family consists of MUSE-T, MUSE-E (full-band MUSE), Narrow-MUSE, and NTSC MUSE-4, all based on the same coding algorithm. All these systems have been demonstrated.

For display on a computer, pictures reduced by $1/2^n$ can be made with only intra-field information. Other ratios require more processing.

This system uses a multiple sub-sampling technique with a four-field sequence. Therefore, the temporal resolution of the reconstructed picture can be controlled by selecting fields to be used for the interpolation. When all four fields are used, full temporal resolution, 1/60 sec, is obtained. To reduce the amount of data, the field repetition rate can be reduced for pictures with less temporal resolution.

The multiple sub-sampling technique makes possible two types of receivers differing in complexity. A simple receiver can be built that handles only intra-field interpolation, while the full-capability receiver handles both intra-field and inter-field interpolation.

The low-frequency component below 2 MHz of the Narrow-MUSE signal does not contain the aliasing component caused by frame offset sub-sampling. Therefore, a picture whose quality is equivalent to NTSC can be reproduced by using only this low-frequency component.

Picture-in-picture, picture-out-of-picture, and multiple programs can be accommodated using only the intra-field information from the Narrow-MUSE signal. A frame store in the receiver can be used for this purpose.

II. Scope of services and features

A. Initial use for ancillary data

The partition of the ancillary data has not been specified yet.

B. Audio

This system provides two audio modes. Both modes employs Near-instantaneous Companding DPCM for coding. Mode A can transmit four audio channels with 15-kHz bandwidth, the data rate of which is 1056 kbps/channel without error protection. Mode B can transmit two audio channels with 20-kHz bandwidth, the data rate of which is 1072 kbps/channel without error protection. Since the data capacity of the audio channel is relatively high, modifications can be made to increase the number of audio channels.

C. Data

This system provides 128 kbps of ancillary data. This can be increased by modifying the audio encoding method. The interface for the data channel is RS-422.

D. Text

Teletext data is transmitted using the ancillary data channel. The proponent suggests a data rate of 16 kbps. He also suggests that the number of characters per picture is between 1000 and 4000, to be transmitted in about 3 seconds. These numbers can vary, based on the service required.

E. Captioning

Captioning data is transmitted using the ancillary data channel. The proponent suggests a data rate of 0.6 kbps. This number might vary, based on the service required.

F. Encryption

The system submitted for testing did not include encryption. The proponent suggests a combination of line rotation and line permutation for signal security. Decoder chips for the encryption system are already developed.

G. Addressing

The proponent claims that the data rate needed for addressing and sending decryption keys is approximately 16 kbps, and that this rate will permit the addressing of 10,000,000 subscribers in approximately two days. However, this addressing rate is not sufficient for a pay-per-view environment. The addressing information is transmitted through the ancillary data channel.

H. Low-cost receiver

This system has two modes in the receiver, i.e. stationary mode and motion mode. The stationary mode requires more memory and a more complicated interpolation than the motion mode. By using only the motion mode, low-cost receivers can be built with reduced resolution. The quality is higher than with NTSC on a 2" LCD receiver because the resolution is almost the same, and neither cross-luminance nor cross-color is observed. The proponent claims that a reduced-cost receiver is already available on the market for the full-band MUSE, and that the same configuration can be used for Narrow-MUSE.

I. VCR capability

The proponent claims that a digitized Narrow-MUSE signal with an 80-Mbps data rate or a DPCM-encoded Narrow-MUSE signal with a 40-Mbps data rate can be digitally recorded on a 1/2 inch cassette VCR. The record/playback time is said to be 4 to 8 hours. Since the bandwidth of Narrow-MUSE is the same as for NTSC, the requirements of a VCR are similar.

Only sync blocks whose ID signals are detected correctly are used for fast forward and reverse. Sync blocks whose ID signals are not detected correctly are discarded, and replaced with interpolated information. The proponent claims that the quality of a rapid search picture will be comparable to that of a 4-head VHS machine.

These functions can be achieved, based on the four-field sequence of the Narrow-MUSE algorithm. Editing functions can be implemented by adjusting the subsampling phases between the materials to be edited, using the subsampling phase information which is transmitted as a part of the control signal. The four-field sequence is similar to that of NTSC.

Special effects are not done with the Narrow-MUSE signal. Rather, they are done on the 1125/60 signal.

III. Extensibility

A. to data rate with no visible artifacts

MUSE-T, a higher member of the MUSE family, has a bandwidth of 16.2 MHz and can provide a picture with no visible artifacts because it employs only intra-field subsampling. A digitized MUSE-T can be further compressed using DPCM without introducing additional artifacts. The main part of a Narrow-MUSE receiver can be shared for MUSE-T decoding when MUSE-T is transmitted through alternate media such as DBS. It is also possible to extend Narrow-MUSE to MUSE-T by transmitting the difference between locally decoded Narrow-MUSE and MUSE-T through an additional channel.

B. to studio quality data

It is possible to extend Narrow-MUSE to 240M by transmitting the difference between the locally decoded Narrow-MUSE and 240M signals through an additional channel as augmentation information. The bandwidth of the studio-quality signal is 60 MHz (30 MHz for luminance signal and 15 MHz for each color difference signal).

C. higher resolution

MUSE-E can be used for higher resolution. The main part of a Narrow-MUSE receiver can be shared for MUSE-E when MUSE-E is transmitted through alternate media such as DBS. It is also possible to extend Narrow-MUSE to MUSE-E by transmitting the difference between locally decoded Narrow-MUSE and MUSE-E through an additional channel.

The proponent suggests that it is possible to extend Narrow-MUSE to VHDTV and UHDTV by transmitting the difference between the locally decoded Narrow-MUSE and VHDTV/UHDTV through an additional channel as an augmentation signal.

D. Provision for future compression enhancement

The proponent claims that the dynamic resolution can be improved by increasing the number of motion vectors. The additional motion vectors can be transmitted through the data channel at the expense of data for other purposes.

JEGI Doc.-019/1

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TO: ACATS Joint Experts Group on Interoperability

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B.Gerovac	Digital	Fax: 617-489-5917
M.Haley	IBM	Fax: 914-892-6799
P.Hearty	ATEL	Fax: 613-592-4398
R.Hopkins	ATSC	Fax: 202-828-3131
C.Tanner	CableLabs	Fax: 303-939-9189

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J.Flaherty	CBS	Fax: 212-975-3646
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DT: 31 Aug 93

RE: Teleconference Call, Friday, 27 August 1993

Correction to the meeting notes, page 3:

The schedule for the letter of invitation should have read:

"30 Aug: letter of invitation redrafted by Sanderson and forwarded to this meeting's participants for comment.

31 Aug: response by participants to draft document.

03 Sep: Final document forwarded to Experts panel."

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DT: 21 Sep 93

RE: JEGI Meeting, 20 September 1993

Attached are the draft meeting notes.

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ACATS Joint Experts Group on Interoperability (JEGI)

Summary Notes - Meeting, 20 September 1993
Eastman-Kodak
1300 North 17th Street
Arlington, VA.

Those present:

ACATS Joint Experts Group on Interoperability

R.Sanderson (Chair)	Eastman-Kodak
M.Liebhold (Vice-Chair)	Apple
S.Baron (Sec.)	NBC
J.Bellisio	Bellcore
T.DeYoung	ARPA
B.Gerovac	Digital
M.Haley	IBM
P.Hearty	ATEL
R.Hopkins	ATSC

Grand Alliance Representatives

R.N.Hurst	DSRC
R.Keeler	AT&T
G.Reitmeier	DSRC

The meeting was called to order by the Chair at approximately 10:00 hrs. with the agenda agreed as follows:

1. Approve notes of August 27 teleconference call meeting.
2. October 6/7 Meeting
   - Location decision.
   - Agenda.
   - SMPTE/MPEG-HD "status"
   - Participant preparation/expectations.
     - Gerovac/Liebhold Action Item.
     - Advanced distribution GA report draft.
     - Documents vs. speeches.
     - Final mailing.
3. Grand Alliance Report Preview

1. August 27 Teleconference Meeting Notes

The meeting notes (JEGI Doc.-014) were approved as minutes (JEGI Doc. 014A) with the following corrections:

1. The dates listed on page 3, for the letter of invitation should have been 30 Aug.,

31 Aug., and 03 Sep. (Stan Baron had already issued a correction notice via fax JEGI Doc.-019).

2. The spelling of the location of this meeting was corrected from "Roslyn" to "Rosslyn".

2. October 6/7 Meeting Discussion

A. Location decision

M.Liebhold reported that two sites were under consideration. One site was at the Library of Congress and members of Markey's staff would assist with the arrangements pending site availability. The second site was at a hotel and a corporate sponsor had been secured. It was expected that a final decision on the location would be made by Wednesday, 22 September.

B. Agenda and
D.Participant preparation/expectations

A draft agenda for the October 6/7 Meeting was presented by M.Liebhold (see attached JEGI Doc.-021). The following decisions were made:

1. It would be desirable to provide a background presentation for those members of the Interoperability Review panel who had not participated in the ACATS process. It was agreed that the presentation:
would best be held at the ATTC,
should be held before the Review meeting began,
should include a presentation of the special panel tape (on artifacts),
should include examples of GI and AT&T transcoding results,
should include picture quality presentations to help calibrate the participants,
should include the source comparison demonstration using the Pixar,
should be held on 5 October in the afternoon (or evening, if possible), and
should plan for two to three sessions to properly accommodate the number of panelists.

R.Sanderson was charged with discussing the possibility for such an arrangement with Peter Fannon with support by the Grand Alliance.

2. The Introductory Session scheduled for 08:30 - 09:00 on 6 October would consist of:

- welcoming comments by Sanderson and Liebhold, and

- introduction of and introductory comments by Wiley, Flaherty, and Dorros as they felt appropriate.

3. The Introduction of Process session scheduled for 09:00 - 09:30 on 6 October would include:

- instructions to the Interoperability Review panel,

- a mission statement,

- background on the relevant work of PS/WP4.

4. Each panelist will be asked to provide, in advance of the meeting, a document describing their area of interest, concerns, expectations, personal and industry perspective, and preliminary reaction to Grand Alliance proposal. The document must include a one page executive summary and should discuss the issues in technical terms.

Each panelist will be given up to five minutes during the afternoon of 6 October to discuss these issues or ask questions of the Grand Alliance or the other panel members.

During the evening of 6 October, the members of the Experts Group will compile the issues for discussion on 7 October.

5. It was agreed that "Testing/Verification Recommendations" would be added to the *Contribution Matrix*.

6. It was agreed that the discussion on the morning of 7 October would be structured rather than open.

C. SMPTE/MPEG-HD Status

B.Gerovac provided a brief update on the status of the on-going work within SMPTE and MPEG on development of a Header-Descriptor with a view on the possible relationship between the work of each of the groups when finalized.

3. Grand Alliance Report Review

G.Reitmeier presented a draft Outline for the Grand Alliance Interoperability Report. The discussion that followed resulted in several suggestions for improvement to the Grand Alliance document.

Summary of Action Items:

1. R.Sanderson to initiate discussions on a demonstration plan with the ATTC by 21 Sep.

2. M.Liebhold to finalize the site selection by 22 Sep.

3. M.Liebhold to finalize revised agenda by 22 Sep.

4. G.Reitmeier to provide draft of GA presentation to R.Sanderson for distribution by 22 Sep.

5. R.Sanderson to complete "final" letter to panelist by 22 Sep.

6. M.Liebhold to provide final mailing list to R.Sanderson by 24 Sep.

7. R.Sanderson: final mailing by 24 Sep.

8. Teleconference call to finalize details on 22 Sep. between 16;00-17:00 hrs (4:00-5:00 PM).

The meeting was adjourned at approximately 16:45 hrs.

September 19, 1993

To: FCC ACATS Joint Expert Group on Interoperability
Robert Sanderson, Chairman

From Mike Liebhold

Subject Location Alternatives
Draft meeting plan and for Interoperability Review

Location alternatives
Library of Congress (pending)
Ramada Rennaissance (Reserved)

Interoperability Review Agenda
Day one: 10/6

- 8:00 Coffee-Continental Breakfast

- 8:30- 9:00 Introductory Remarks
  R. Sanderson, Chair — R. Wiley *TBD*
  M. Liebhold, Vice Chair — J. Flaherty *TBD*
  Members of Joint Experts Group

- 9:00-9:30 Introduction of Process

Instructions to Interoperability ReviewBoard:

This process is designed as a collaboration between the GA and 'Stakeholder Communities' to gather best technical contributions on Interoperability for the US ATV standard. In order to facilitate the final report. We request comments and contributions be as detailed as possible and structured within the following framework:

> Each Review board member is supplied with a 'Contribution Matrix mapped directly to the structered presentation of the GA (G. Reitmeir's proposed table of contents) Please comment on *Interoperability* , section by section of the GA design proposal - as appropriate to your community, industry, or constituency:

	Near-Term	Long-Term
Technical Suggestions		
Economic Cost/Benefits		
Social/Community Tradeoffs		

Interoperability Review Agenda (continued)

Day one: 10/6 (continued)

- 9:30-12:00 GA presentation (Break 10:15-10:30)

  - Including Brief Q&A after each presentation section

- 12:00-1:00 Lunch

- 1:00-5:00 Formal Statements and Questions (Break 2:45-3:00)

  - Interopability Review Board and Joint Experts (5 min. each):

Day two : 10/6

- 8:00 Coffee-Continental Breakfast
- 8:30 - 12:00 Open Discussion - section by section GA Report
- 12:00 -1:00 Lunch
- 1:00 - Open Discussions - Report process and Calender of deliverables

need dates

Collect Contributions
Draft Report
- Majority/Minority positions for each section

IOB Review/Comment of Draft
Final Report to ACATS

- 3:00 adjourn

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4) NO FACSIMILE CONNECTION

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cc:	J.Flaherty	CBS	Fax: 212-975-3646
	I.Dorris		Fax: 201-285-0679
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